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REPORT OF ACTIVITIES

Second Quarter 1995

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Editor: Esther Perez
Layout: Roy Allen

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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Collaborative Study in the Bay of La Paz, Mexico

Fishery Biologist Roger Hewitt and Ocean Acoustics Engineer David Demer participated in a research study to investigate the role of low-frequency sound (LFS) in the foraging ecology and behavior of whales of the genus *Balaenoptera* (also called rorqual whales), including fin whales (*Balaenoptera physalus*), Bryde's whale (*Balaenoptera edeni*), and blue whales (*Balaenoptera musculus*). The two-year project is funded by the Office of Naval Research, and the principal investigator is Donald Croll, University of California at Santa Cruz.

The objectives of the study are to examine (1) whether LFS is used by foraging rorqual whales, (2) the frequencies and sound levels these animals encounter and use in an area with high human use (Monterey Bay, California) and low human use (Bay of La Paz, Mexico), and (3) whether man-made LFS has the potential to interfere with acoustic signals associated with rorqual whales during foraging, traveling, and social interactions. It is hoped that this study will provide essential data on the use and importance of LFS to foraging rorqual whales. The researchers will examine the role of LFS in prey detection, recognition of oceanographic features, and the maintenance of social integrity in rorqual whales. A comparison of the use of LFS by rorqual whales in areas of high and low levels of man-made LFS will aid in evaluating the potential impact of man-made LFS on the whales' foraging behavior and ecology. Sources of man-made LFS include ship traffic (merchant and naval ships, fishing and scientific vessels, offshore supply vessels); offshore industrial activities (seismic exploration, construction work, oil and gas drilling activities); and acoustic thermography. There is some public concern about the possible detrimental effects to marine mammals from LFS produced for acoustic thermography and ocean climate experiments.

During spring of 1995, the study was conducted in the Bay of La Paz from various ship platforms during several short-duration cruises. Using a crossbow, recoverable electronic devices were deployed onto rorqual whales in known foraging areas. These devices contained the following instrumentation: (1) a microprocessor-controlled

time-depth recorder (TDR), (2) a VHF radio transmitter to allow tracking of the tagged animal for extended time periods by ship, and (3) a radio activated release mechanism. The tagged animals were tracked by ship while concurrently measuring (1) prey distribution in the water column using a high-frequency hydroacoustic system, (2) water column temperature using a portable bathythermograph, and (3) ambient LFS levels and acoustic signal emissions by the tracked whales using a low-frequency two-hydrophone array.

Hewitt and Demer were involved in the examination of the distribution of prey in relation to the diving behavior and movements of the tagged whales. Using a portable SIMRAD hydroacoustic system with 38 kilohertz (kHz) and 200 kHz hull-mounted transducers, the horizontal and vertical distribution of the whales' prey was monitored. In concert with acoustic operations, prey concentrations were sampled with plankton nets. The net samples were analyzed for prey species and size identification.

The hydroacoustic operations were very successful, and Hewitt and Demer were able to map the prey field of the entire Bay of La Paz. In addition, using data from both the hydroacoustic system and TDRs deployed on the tracked whales, they were able to identify layers in the water column where the rorqual whales were foraging. Also, collected net samples, as well as whale fecal samples, confirmed the species composition of the foraged layers to be primarily the euphausiid *Nyctophanes simplex*. Both Hewitt and Demer will be involved in the study of the distribution of rorqual whale prey in Monterey Bay.

International Symposium on Fisheries and Plankton Acoustics

Demer and Hewitt spent one week in June at the International Council for the Exploration of the Sea (ICES) Symposium on Fisheries and Plankton Acoustics in Aberdeen, Scotland. This meeting was the fourth in a series of symposia on the subject of acoustics organized by ICES over the last 22 years. Three hundred scientists from some 31 countries attended talks and poster sessions on biological aquatic acoustics, reviewing the collection and uses of acoustic data and identifying areas for development in future studies.

Demer collaborated with Linda Martin, Woods Hole Oceanographic Institution, and they presented a talk on "Zooplankton target strength: volu-

metric or areal dependence?" They measured the target strengths of various zooplankton at 200 kHz, 420 kHz, and 1 megahertz (MHz), and the dependence of these data on animal volume versus cross-sectional area was explored. Hewitt and Demer gave a talk on "Lateral aspect target strength of Antarctic krill," in which in situ measurements of krill target strength collected with a side-looking transducer were presented.

Hewitt and Demer worked with two scientists from the Alaska Fisheries Science Center, Jeff Napp and Ric Brodeur, to present a talk on "Acoustic determination of plankton and nekton concentrations at tidally generated shelf fronts in the Eastern Bering Sea." On the southeastern Bering Sea shelf, two different spring and summer tidally generated fronts exist. Around the Pribilof Islands, these fronts are thought to be sites of elevated feeding activity for migratory marine birds and mammals that use the islands to rear their young. The survival and reproductive success of the birds and mammals are likely tied to the abundance of late larvae/early juvenile walleye pollock (*Theragra chalcogramma*) found in this region. A two-ship biophysical experiment was conducted in the vicinity of the Pribilof Islands to determine whether or not the fronts were sites of (1) elevated fish and plankton concentrations and (2) elevated feeding activities for the pollock and higher trophic levels. Once the position and width of the fronts were defined, Hewitt and Demer conducted acoustic measurements during transects across the fronts. Specific acoustic signatures of fry pollock and other zooplankters were identified using a variety of net sampling gear to collect insonified animals. Results from this collaborative work were presented in the paper.

In addition, Hewitt and Demer presented two posters at the meeting. The first was "Antarctic krill aggregation patterns as inferred from acoustic surveys." In their presentation, data from a series of acoustic surveys conducted during the 1990-94 Antarctic Marine Living Resources Program's research cruises in the vicinity of Elephant Island, Antarctica, were examined for evidence of non-random dispersion in krill. Demer and Hewitt also presented a second poster, "In situ target strength measurements of Antarctic zooplankton (*Euphausia superba* and *Salpa thompsoni*) at 120 kHz and 200 kHz, corroboration of scattering models, and a statistical technique for delineating species." Both posters were very well received at the symposium. (J. Rosenberg, [619] 546-5600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

Adaptive Sampling for Pacific Whiting Larvae

Large sample sizes are normally required to precisely estimate abundance of highly aggregated fish larvae, like those of Pacific whiting (*Merluccius productus*). Precision is a problem because of the high variance in the number of larvae per sample or plankton tow. Often, for example, most of the Pacific whiting larvae captured in a plankton survey are taken in a few tows that happen to encounter aggregations of larvae.

Adaptive sampling is an alternative to random sampling designs. Adaptive sampling can provide more precise abundance estimates with relatively small sample sizes. The approach was developed in the early 1960s for terrestrial surveys and has been improved considerably in recent years (Steven K. Thompson. Sampling. John Wiley & Sons, Inc. 1992). In essence, adaptive sampling is a sampling design in which the procedure for selecting sample sites and allocating sampling effort depends on data collected during the survey.

Adaptive sampling was used to survey Pacific whiting larvae during March 1995 (Fig. 1). The survey area was divided into rectangular strata with two base stations in each stratum except for strata 11 and 18 which had three stations each. Base stations in each stratum were sampled using bongo nets and the number of Pacific whiting larvae in each tow was determined immediately while the boat proceeded to the next station. If any bongo sample contained more than a specified number of larvae, then four additional stations were added to the stratum. If any of the four additional stations contained more than a specified number of larvae, then two additional stations were added to that station. Thus, there could be between 2 and 14 stations per stratum depending on the number of whiting larvae taken. In Pacific whiting larvae, variance among tows is positively correlated with larvae abundance. Adaptive sampling allocates larger sample sizes to strata where larvae are common and reduces variance.

The survey was conducted between California Cooperative Oceanic Fisheries Investigation (CalCOFI) lines 66.7 and 90.0 (Fig. 1). The survey area

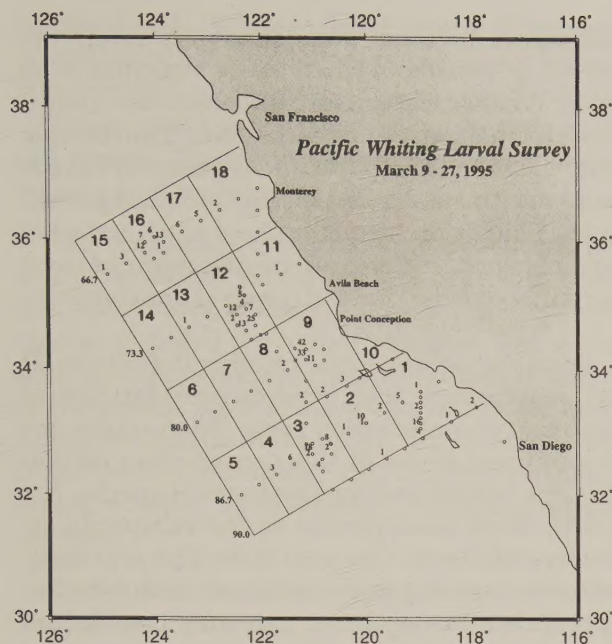


Figure 1. Stations occupied and strata in the 1995 survey for Pacific whiting larvae. Small numbers are the number of larvae caught at each station. Large numbers identify strata. Decimal numbers identify CalCOFI lines.

was divided into 18 strata (stratum 10 was excluded from analyses because only one station was occupied). Based on CalCOFI data for 1993-94, sampling was increased if any samples at base or subsequent stations in a stratum contained more than 20 Pacific whiting larvae. After lines 80.0 and 86.7 were occupied, the criteria were reduced from 20 to 10 larvae. The total number of stations occupied for the whole survey was 102. After stratum 18 was completed, a total of 49 stations were occupied for the adaptive sampling. Because most stations did not contain any larvae, extra ship time was available to occupy areas that had relative large amounts of larvae in the early part of the cruise.

To evaluate the efficiency of different sampling designs for Pacific whiting larvae, stratified sample means and standard errors were computed for six sampling designs:

- (1) Stratified sampling (SS) - 38 base stations along four CalCOFI lines.
- (2) Stratified sampling (SS1) - 49 stations allocated proportionally to strata.
- (3) Stratified sampling (SS2) - 101 stations allocated proportionally to strata.
- (4) Adaptive stratified sampling (ASS) - 49 stations.

- (5) Adaptive stratified sampling for the whole survey area (ASSW) - 101 stations.
- (6) Simple random sampling (SRS) - assuming 38 stations were drawn randomly from study area.

The efficiency of a sampling design was measured by the inverse of the ratio of its variance to the variance of the stratified sampling design (SS). For example, the efficiency of adaptive stratified sampling relative to stratified sampling was $\text{Var}(\text{SS})/\text{Var}(\text{ASS}) = 4.17$.

Results (Table 1) indicate that adaptive sampling (ASS) performs better than stratified sampling (SS1). As expected, simple random sampling (SRS) was the poorest design of all. To compare adaptive and stratified random sampling directly, we computed $\text{Var}(\text{SS1})/\text{Var}(\text{ASS}) = 2.51$. Thus, for a sample size of 49 stations, the variance in estimated Pacific whiting larvae abundance using stratified random sampling was about 2.5 times larger.

Increased sample size made both stratified sampling (SS2) and adaptive sampling (ASSW) more precise (Table 1). The efficiency of adaptive sampling relative to stratified random sampling with 101 stations was $\text{Var}(\text{SS2})/\text{Var}(\text{ASSW}) = 7.01$. Thus, the efficiency of adaptive sampling relative to stratified random sampling seems to increase with sample size.

Table 1. Mean densities of Pacific whiting larvae with standard errors and number of tows for six sampling designs. Efficiency of each sampling design is computed relative to stratified sampling (SS).

Design	Mean Density	Standard Error	CV %	Relative Efficiency	N
SS	3.75	0.898	24	1.00	38
SS1	3.75	0.696	19	1.66	49
SS2	3.75	0.339	9	7.06	101
ASS	2.96	0.439	15	4.17	49
ASSW	2.37	0.128	5	48.8	101
SRS	3.50	1.065	30	0.71	38

Estimates of Pacific whiting abundance based on adaptive sampling were underestimated by about 15 percent. Unbiased estimators for adaptive sampling are available but require that all individuals in a strata be counted, which is impossible for larval surveys. We are currently investigating approaches to estimate and correct for bias introduced by adaptive sampling. (N.C.H. Lo, [619] 546-7123; Internet: nlo@its.ucsd.edu)

MARINE MAMMAL DIVISION

La Jolla, California

Report Presented to the IWC on the Genetics Workshop Hosted by the SWFSC

The Report of a Workshop on Analysis of Genetic Data to Address Problems of Stock Identity as Related to Management was presented to the Scientific Committee of the International Whaling Commission (IWC) in Dublin, Ireland, during May 1995 (Dizon et al. 1995). The workshop was held in La Jolla, California, from September 26-28, 1994, at the Southwest Fisheries Science Center (SWFSC). Support for the meeting came from the U.S. Marine Mammal Commission and IWC, as well as the NMFS Office of Protected Resources and the SWFSC. Thirty-three talks and posters were presented.

The impetus came from the 1994 amendments to the Marine Mammal Protection Act (MMPA) that require NMFS and the U.S. Fish and Wildlife Service (USFWS) to complete stock assessment reports for all marine mammal stocks within U.S. waters. These stock assessments must include, among other things, information on how stocks were defined. The symposium and workshop were convened because the MMPA amendments provided only limited guidance on the definition of stocks, and because there is a clear need to establish, where possible, appropriate, quantitative criteria that may be consistently applied to marine mammal stocks between regions for developing stock assessment reports.

Status assessments of marine mammals require knowledge of intraspecific population structure, but defining biologically meaningful stock units for use in management situations has always been a problem. In the past, a variety of data, including molecular genetic data, has contributed to unraveling the complexities of intraspecific structure. Although the molecular genetic role has been small, incredibly rapid progress in that area is likely to increase its contribution in the future. To take advantage of this progress, methodologies for molecular phylogenies, gene flow, population growth rates, and dispersal distance should be available, but there has been growing realization that this area is complex and pitfall-ridden, especially when the methods are applied to incompletely isolated populations. Fixed allelic

differences between populations are rarely observed in situations where stock structure is an issue. When stock structure is a conservative issue, modal or frequency differences rather than absolute differences between populations generally have to be invoked to subdivide a species into management units. Equally problematic is how much and what type of genetic differences are diagnostic of stock units in both biological and conservation contexts.

Formulation of genetic or other definitions of the management unit requires consideration of the intent of conservation goals. For instance, the two primary pieces of U.S. conservation legislation, the MMPA and the Endangered Species Act (ESA), direct management to the subspecific or intraspecific level. One goal of the ESA is to minimize the loss of genetic variation, and, here, an appropriate management unit may best be defined in terms of the evolutionary significance of such variation. The MMPA, in contrast, requires that marine mammal populations be maintained at levels at or above their optimum sustainable population level (at or above approximately 50 percent of historical abundance) and as functioning elements of the ecosystem. This implies a risk-averse management approach in that the costs of potentially losing important subpopulations are considered greater than the costs of potentially over-restricting commercial fisheries. The management objective to maintain populations at quite high levels under the MMPA requires a more demographically based definition than the ESA. Calculating the number of animals that fisheries may remove necessitates estimating population structure (exchange rates between management units) as well as abundance, population growth rates, and incidental fishery mortality.

Specific objectives of the workshop were to first review the current state of knowledge, particularly intraspecific genetic studies on marine mammals and other relevant species, and to review selected developments in current analytical techniques. The balance of the workshop was to be devoted to (1) a discussion of the role of genetics in examining population structure under conditions of relatively high rates of interchange and (2) the important role of statistical power in applying genetic data in conservation management situations. To properly apply genetic investigations to management decision making, both the probability of false rejection (α) and false non-rejection (β) of a null hypothesis must

be considered. Failure to detect genetic differences should not be used to pool two putative populations into a single management unit unless an estimate of statistical power is made and an appropriate level of β elected. The workshop examined methods for making such an estimate.

The workshop discussed humpback whales and other baleen whales, pinnipeds, marine turtles, polar bears, walruses, and sea otters. Cased studies included the harbor porpoise, Steller sea lion, bottlenose dolphin, and beluga whale. Some of the genetic tools discussed included the latest in microsatellite technology, extracting DNA from "problem samples," data quality, and combining nuclear, mitochondrial, and morphological data.

Eight recommendations were made during the workshop:

- (1) Participants at the workshop recommended that basing management units on mtDNA evidence of female philopatry is biologically sound regardless of male-mediated nuclear gene flow.
- (2) The workshop participants concurred that the genetic data were of sufficient strength to warrant subdividing the Steller sea lion into two genetically distinct units.
- (3) A concerted effort should be made to obtain samples, sequence the samples, and develop a data bank of mtDNA control region haplotypes (hypervariable region I) for all species, subspecies, and stocks of marine mammals, worldwide. This would serve to establish a reference library that can be used to assist in the identification of the species and stock of origins of tissues from unknown or uncertain sources. A first step should be an inventory to identify work that has already been done.
- (4) Every effort should be made to obtain and preserve amplifiable tissue samples from all possible sources commensurate with national and international wildlife laws and good conservation practice. Possible sources of materials for both general and specific genetic analyses included stranded animals, animals caught incidentally in fisheries, and animals taken by subsistence hunters, researchers, etc. Mechanisms should be established to increase awareness of the need for these materials and to pro-

vide incentives for collecting and supplying samples.

- (5) Consideration should be given to establishing one or more "service" laboratories where specimen materials can be sent for quick, inexpensive typing.
- (6) Individuals and agencies responsible for authorizing the collection, import, and export of various types of materials used in genetic analyses should be contacted to i) ensure that they are aware of the problems caused by restrictive regulations and slow processing of permit applications, ii) determine the sources of the problems, and iii) identify activities to overcome the problems. Scientists having difficulty conducting legitimate research because of problems obtaining import, export, or collection permits quickly should ensure that those responsible for establishing and implementing policies and regulations are aware of the problems and how they could be avoided.
- (7) All published sequences and probes should be submitted to a sequence data bank.
- (8) In situations where stock-structure decisions may be based on negative data, the workshop participants strongly suggested that it is the responsibility of the investigator providing data either to provide estimates of the probability of making a type II effort, namely, incorrectly rejecting the null hypothesis, or to provide sufficient caveats regarding the likely low level of statistical power. It is unacceptable that decisions to pool putative subpopulations for management purposes be based solely on failure to find evidence of subpopulation discreteness.

Results of this workshop will help refine, coordinate and improve genetic stock separation methods for determining population structures of cetaceans and other protected marine species to help better identify, reduce, or prevent adverse interactions between human activity and the most vulnerable stocks.

The proceedings will be submitted as a NOAA Technical Report in October 1995 and will consist of the report of the workshop, as well as 23 symposium and workshop working papers. (A. Dizon, [619] 546-7089)

HONOLULU LABORATORY

Honolulu, Hawaii

PROTECTED SPECIES INVESTIGATION

Seven Hawaiian Monk Seal Yearlings Released at Kure Atoll

On May 14, 1995, seven Hawaiian monk seals were released at Kure Atoll, at the northwestern end of the Hawaiian Archipelago. The seals, all yearling females, had been collected as pups at French Frigate Shoals (FFS) during the period May to July 1994 and had undergone 10 to 12 months of rehabilitation at Sea Life Park Hawaii. An additional female had been collected but died 18 days after collection. The remaining seven, including one that was collected after losing a hind flipper to a shark, responded well to rehabilitation, and all were released in excellent condition.

The seals were flown from Oahu to Midway Atoll on board an Air Mobility Command flight of the U.S. Air Force. At Midway, they were met by the NOAA charter vessel *Glorita* and transported to nearby Kure Atoll. Upon arrival at Kure, the seals were immediately released, and their activities are currently being monitored by field biologists from the University of Hawaii and the Hawaii Department of Land and Natural Resources. The success of this translocation will eventually be evaluated on the basis of the animals' survival in the wild, but to date they appear to be adapting to the Kure environment.

The release of these seven seals was the latest in an annual series of translocations that began with the collection of seven weaned pups at FFS in 1984. The majority of seals have been released at Kure and many of them are now reproducing and contributing to the recovery of that population. Although the survival rate of 18 seals released at Midway in 1992 and 1993 was far lower than observed at Kure, rehabilitation and translocation are expected to play a key role in future management efforts to enhance the recovery of the monk seal population at Midway.

Virtually all of the seals that have been rehabilitated and translocated were born at FFS. The resident population of seals at this site grew substantially from the late 1950s to the mid-1980s

but has declined sharply since 1989. The ultimate cause of the decline is not altogether clear, but the immediate cause appears to be low prey availability with subsequent starvation and mortality of juveniles. The translocation efforts are intended to salvage the reproductive potential that is vital to the recovery of this species but is otherwise lost with such high mortality. (T. Ragen, [808] 943-1280)

Honolulu Laboratory Hosts Turtle Survivability Workshop

The Honolulu Laboratory hosted a workshop on Turtle Handling, Resuscitation, and Avoidance, March 15-17, 1995. Participants included marine turtle biologists and veterinarians, NMFS at-sea observers, and representatives from the longline fishing industry. A scientist and a fishing industry representative from Japan also participated in the workshop. Hawaii longline fishermen have been asked to provide their comments on the preliminary workshop recommendations.

The primary objective of the workshop, as agreed upon by the participants, was to prepare practical guidelines for improving the survivability of marine turtles taken incidentally in the Hawaii longline fishery. These guidelines will be prepared in response to the NMFS Biological Opinion (July 25, 1994) concerning interactions between the Hawaii domestic longline fishery and protected marine turtles.

Workshop participants examined the background of the Hawaii longline fishery, the experiences of the NMFS observers, and marine turtle physiology. Participants prepared detailed recommendations for both fishermen and observers, covering fishing vessel operations, procedures for retrieving and releasing turtles, and methods for assessing and treating hooked or entangled turtles. Workshop guidelines, which will include recommendations for determining long-term assessment of the effectiveness of turtle survivability measures, will be used to educate fishermen and to implement current regulations.

The workshop guidelines will be presented in a Honolulu Laboratory administrative report that will identify their rationale, their advantages and disadvantages, and detailed measures for implementation where appropriate. These guidelines will be reviewed by the Southwest Region, in consultation with NMFS Headquarters, to determine whether formal regulatory action will be required. (G. Balazs, [808] 943-1240)

ECOSYSTEM AND ENVIRONMENT INVESTIGATION

Possible Link Between Bluefin Tuna Migration and Sardine Abundance Investigated

During the past year, Hawaii-based longline vessels reported sporadic catches of northern bluefin tuna, *Thunnus thynnus*, north of the Hawaiian Islands. Given the high value of these fish and the possibility that they could be targeted by the fishery, Fishery Biologist Jeffrey Polovina reviewed the current research on their population dynamics. Tagging data suggest that northern bluefin tuna spawn only in the western Pacific and that a portion of the juveniles migrate to the eastern Pacific. During the past decade, catches of northern bluefin in the eastern Pacific have declined. One cause for this decline that has been proposed as a result of bluefin stock assessment studies is a decline in the proportion of bluefin that migrate out of the western Pacific. Polovina examined several indices of the relative abundance of bluefin tuna in the western and eastern Pacific. Apparently, fewer bluefin are migrating to the eastern Pacific since 1977. This period of reduced bluefin migration coincides with the period when a prey of bluefin, Japanese sardine, *Sardinops melanosticta*, are abundant in the western Pacific. Polovina hypothesizes that in years when sardines are abundant in the western Pacific, a higher proportion of bluefin stay in the western Pacific compared to years when sardines are scarce. Currently, sardines are declining in abundance in the western Pacific, and if this decline continues, an increase in bluefin migrating north of Hawaii and into the eastern Pacific may occur. (J. Polovina, [808] 943-1218)

FISH BIOLOGY AND ECOLOGY INVESTIGATION, LIFE HISTORY PROGRAM

Paper Completed on Interdecadal Changes in Northwestern Hawaiian Islands Reef Fishes

The FFS population of the endangered Hawaiian monk seal, *Monachus schauinslandi*, has declined by 40-45 percent since 1989. A major factor contributing to this decline has been the recent poor survivorship of young seals; one current working hypothesis is that declines in the reef-based forage of seals (reef fishes, lobsters, octopuses) have resulted in an increased incidence of starvation in young animals.

To address the issue of potential changes in reef fish prey, estimates of reef fish densities were com-

pared based on time periods about a decade apart when reef fish abundances likely differed at FFS and at higher-latitude reefs and banks in the Northwestern Hawaiian Islands (NWHI). Specifically, fish faunas were compared between "baseline" diver surveys conducted during 1980-83 at FFS and in 1980 at Midway Atoll by the USFWS, and "recent" surveys conducted in 1992 (at FFS) and in 1993 (Midway) by the Honolulu Laboratory. Species composition, assemblage structure (density rankings), and population densities were compared as a test of the hypothesis that reef fishes had declined since 1988 from abnormally high levels during 1977-88, a period of greater oceanic productivity in the central North Pacific (Polovina et al. 1994, Fish. Oceanogr. 3:15-21; Deep-Sea Res. 1996, in press).

Researchers evaluated possible confounding of temporal patterns among divers both within and between surveys. Surveys were matched by station, and "before-minus-recent" differences in densities were used to control for spatial heterogeneities and reduce variances. A nonparametric bootstrapping procedure was required by the small sample sizes and variability among stations. *P* values were adjusted for multiple comparisons.

Within each of two principal habitats (barrier and patch reefs) at each atoll, the species composition and rank densities of reef fishes differed little between sampling periods. Densities, however, generally declined by about one-third for many numerically dominant species and for taxa pooled into functional categories (trophic levels and feeding guilds; Fig. 1), with taxa classified by the trophic level of prey that dominated diets. Fish densities decreased overall at both atolls for total fishes and pooled carnivores.

Changes in climate and oceanic productivity on an interdecadal time scale likely contributed to the declines in reef fish densities observed at both atolls. Assuming proportionality of density and abundance and an average production-to-biomass ratio of 1.5, a one-third decline in reef fish stocks approximates the halving indicated by Polovina et al.'s estimates of declines in planktonic production.

Based on these temporal comparisons, the statistical power necessary to detect changes in the population densities of individual fish species that exhibit large temporal fluctuations in numbers, particularly on oceanic islands, is generally low. Power to detect twofold changes may be adequate, however, if taxa are pooled into functional categories.

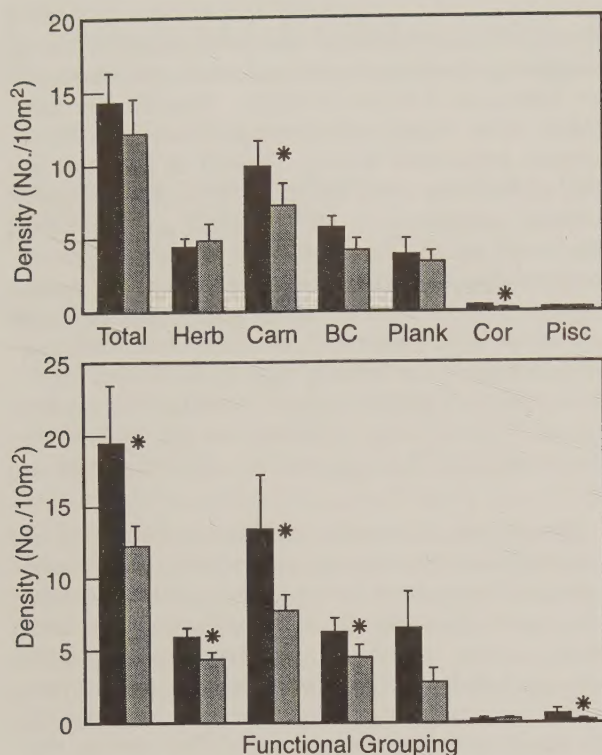


Figure 1. Numerical densities (No./10m²) for total fishes (Total), herbivores (Herb), all carnivores (Carn), benthic carnivores (BC), planktivores (Plank), corallivores (Cor), and piscivores (Pisc), during the respective baseline (dark-shaded) and recent (light-shaded) periods at French Frigate Shoals (top) and Midway Atoll (bottom). Estimates are unweighted grand means for two major habitat types (barrier and patch reefs). Standard errors are noted by lines above histograms. (* indicates a baseline-recent difference that was significant at $P \leq 0.05/m$.)

The paper is scheduled to be published in the May 1996 issue of the *Bulletin of Marine Science* (volume 58, number 3). Copies of the final typescript are available upon request. (E. DeMartini, [808] 943-1234)

FISH BIOLOGY AND ECOLOGY INVESTIGATION, LIFE HISTORY PROGRAM

Barotrauma-associated Regurgitation of Food Described for Juvenile Pink Snapper

The collection of deep-water physoclistous fishes using standard gears such as set lines and trawls typically subjects specimens to large reductions in

ambient pressure (barotrauma) or other (for example, mechanical) stresses as gears are retrieved. Diet and feeding habit characterizations based on such specimens are often unavoidably biased to a large but unknown extent by the loss of stomach contents resulting from regurgitation.

One important aspect of the Honolulu Laboratory's studies of the distributional patterns of pink snapper, *Pristipomoides filamentosus*, juveniles has been quantifying the likely strong links between juvenile snapper diet, prey, and habitat on Hawaiian insular shelves. Diver-Biologists Edward DeMartini, Frank Parrish, and Denise Ellis, therefore, conducted a series of field experiments in 1994 with the objective of evaluating whether a practical technique could be developed for quantifying the stomach contents of pink snapper juveniles with acceptable accuracy and precision. The summary that follows describes a method of collecting juvenile snapper for diet analysis that minimizes the problem of subsurface regurgitation of food as specimens are retrieved from depth.

Juvenile (128-244 mm fork length) pink snapper were caught by hook and line from 60-90 m bottom depths offshore Kaneohe Bay, windward Oahu, Hawaii, during February-August 1994. About one-half of 180 specimens were intercepted randomly by scuba divers 15-18 m below the sea surface and placed live in individual canvas envelopes ("bagged") before they were retrieved the remaining distance to the surface. The other half were retrieved by fishing line directly to the surface ("unbagged"); these latter fish thus typically regurgitated stomach contents when pressure changed. Bagged and unbagged fish of equivalent average body size were collected on nine sampling dates, and the time of collection and extent of stomach eversion were recorded.

The retained stomach contents of bagged and unbagged fish were further compared based on volume and type of food and the size of individual prey items. Growth and other temporal effects required partitioning the data by sampling date; prey volumes were compared between bagged and unbagged treatments using a nonparametric bootstrapping procedure.

Bagged samples of juvenile snapper on average "retained" 116 percent (95 percent CI = 70-157 percent) greater volume of prey than unbagged snapper (Fig. 2), although complete loss of prey (totally empty stomachs; $N = 4$) rarely occurred for

unbagged snapper only. Bagged samples retained a greater variety of prey and more types of prey overall than unbagged samples. Bagged specimens also "retained" prey of greater maximum body sizes.

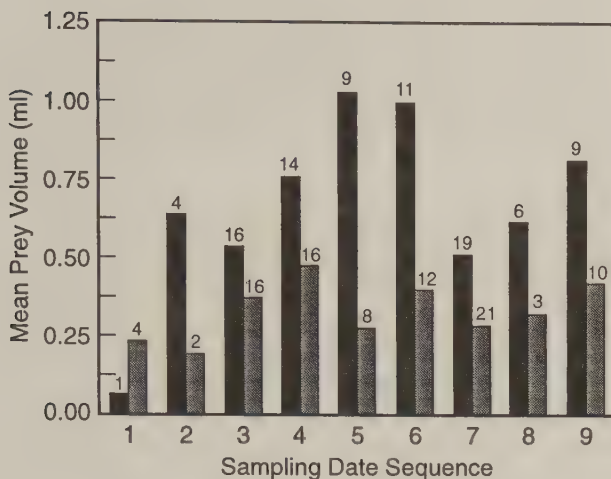


Figure 2. Mean prey volume (milliliters) for bagged (dark-shaded histograms) and unbagged (light-shaded histograms) juvenile pink snapper collected on each of nine dates during February-August 1994. Number of sample fish is noted above histograms.

The results thus clearly demonstrated that designing quantitative diet studies for deep-water physoclistous fishes like juvenile snapper requires careful consideration of the potential importance of selective loss of stomach contents. Depending on the specific research question being asked, collecting specimens for diet and food habits characterizations without adjustment for the regurgitation of certain types and sizes of prey can result in seriously biased results.

A paper describing the study was submitted in March 1995 for publication in the *U.S. Fishery Bulletin*. Additional details are available upon request. (E. DeMartini, [808] 943-1234)

FISHERY MANAGEMENT AND PERFORMANCE INVESTIGATION

Northwestern Hawaiian Islands Fishery, 1994

The Federally managed NWHI bottomfish fishery landed 201,000 kg (444,000 lbs) of bottomfish in 1994, surpassing the annual landings of the last 5 years. The 140 trips made were also at an all-time high for the same time period (Fig. 3). The

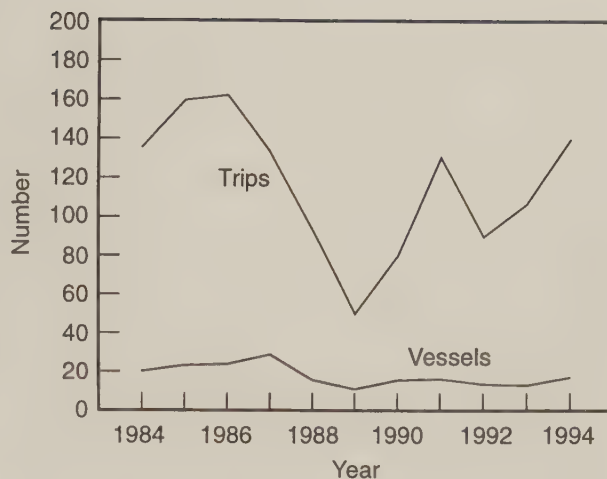


Figure 3. The Northwestern Hawaiian Islands bottomfish fleet--annual number of participating vessels and trips, 1984-94.

number of vessels fishing increased from 12 in 1993 to 16 in 1994.

The fishing activity occurs in two areas: the limited-entry Ho'omalulu zone and the open-access Mau zone. The Ho'omalulu zone was fished by five vessels whose fishing areas ranged from 900-2200 km (500-1200 nmi) encompassing nearly the entire zone. The distances traveled were necessary to locate concentrations of bottomfish needed. The Mau zone was fished by 12 vessels. The transit distance to the fishing area ranged from 460-740 km (250-400 nmi). These vessels made approximately the same average number of trips annually as the Ho'omalulu zone vessels but spent only half as much time at sea. The shorter travel distance also resulted in the landing of good quality fish which, consequently, commanded a higher price, thus enabling the vessels to operate on small catches.

Landings of the primary target species opakapaka, *Pristipomoides filamentosus*, which have been increasing over the previous 4 years, dropped to the 1992 level of 66,000 kg (145,000 lbs; Fig. 4). Landings of the onaga, *Etelis coruscans*, which have been experiencing alternating highs and lows over the last 4 years have broken the pattern and increased slightly over last year's landings. Uku, *Aprion virescens*, landings, which also have been experiencing large fluctuations, more than doubled in 1994. Landings of other species have not fluctuated greatly over the last year.

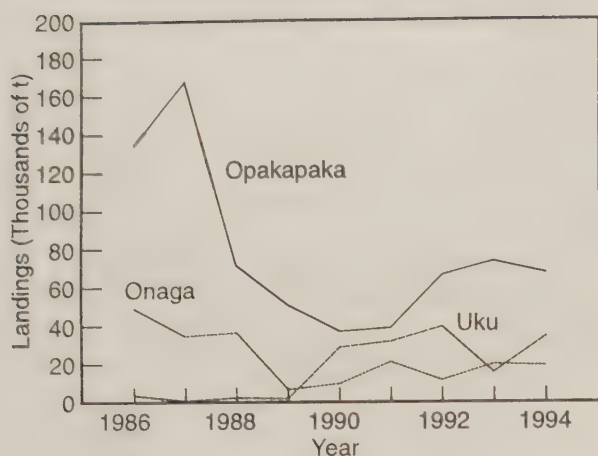


Figure 4. Landings of the primary target species opakapaka, onaga, and uku, 1986-94, from the Northwestern Hawaiian Islands.

A detailed assessment of the NWHI bottomfish fishery will be available from the Honolulu Laboratory. (K. Kawamoto, [808] 943-1252; Internet: kkawamot@honlab.nmfs.hawaii.edu)

Northwestern Hawaiian Islands Lobster Fishery, 1994

During the 1994 lobster season, only 5 of the 15 permit holders fished (the fewest permittees to participate in the fishery since the lobster fishery management plan [FMP] was implemented), with resulting landings and revenue also at the lowest level in the history of the FMP-regulated fishery. The other 10 permit holders decided to sit out the 1994 lobster season or to participate in other fisheries primarily because of the low quota and shortened fishing season.

In order to provide a preseason estimate of the 1994 commercial lobster fishery catch-per-unit effort (CPUE) and quota, all available commercial data from 1983 through 1992 were evaluated by the Honolulu Laboratory's Stock Assessment Program, using a dynamic production model to simulate the effect of the 1993 closure on the NWHI lobster population. Based on the model's estimate of July 1994 CPUE, the preseason or initial quota forecast of 200,000 spiny and slipper lobsters combined was announced in February 1994 (*Federal Register*, 59 FR 6912).

In May 1994, the annual lobster assessment expedition conducted by the NOAA ship *Townsend Cromwell* to the NWHI found CPUE values at Necker Island and Maro Reef to be very close to those predicted by the dynamic production model. However, after the commercial lobster fishery opened on July 1, 1994, CPUE values during the first month of fishing based on call-in catch reports were below the model forecast CPUE and also fell below the FMP target CPUE level of 1.0 lobsters per trap-haul. The commercial CPUE values collected during July 1994 were used in the FMP quota formula to establish a final quota of 21,000 lobsters (only 10 percent of the initial quota). As a result, the fishery closed on August 25, 1994, on an emergency basis after less than 8 weeks of fishing.

During the July-August 1994 season, 131,000 legal spiny, *Panulirus marginatus*, and slipper, *Scyllarides squammosus*, lobsters were landed, with a total estimated weight of 72 metric tons (t) and a total gross revenue of \$837,000. No direct comparison can be made to 1993 because of the fishery closure that year, but during the same period in 1992, approximately 220,800 legal lobsters (106 t) were landed, with an estimated value of \$1.1 million.

Total effort during 1994 was 168,500 trap-hauls compared to 721,700 during 1992. Combined spiny

Table 1. Annual fishing effort (days fished and trap-hauls) and catch-per-unit effort (CPUE; number of lobsters per trap-haul) for spiny and slipper lobsters in the Northwestern Hawaiian Islands, 1994. Data are from vessel logbooks.

Area	Days fished (No.)	Trap-hauls (No.)	Catch-per-unit effort							
			Spiny lobster				Slipper lobster			
			Legal	Sublegal	Berried	Total	Legal	Sublegal	Berried	Total
Necker	102	80,708	0.61	0.39	0.27	1.28	0.21	0.03	0.03	0.27
Gardner Pinnacles	69	69,259	0.43	0.40	0.22	1.04	0.18	0.20	0.08	0.46
Other ^a	28	18,531	0.36	0.10	0.09	0.55	0.89	0.59	0.17	1.65
Total	199	168,498	0.51	0.36	0.23	1.10	0.27	0.16	0.07	0.50

^aIncludes totals for less than three vessels that fished at other Northwestern Hawaiian islands, banks, reefs or shoals.

and slipper lobster CPUE increased to 0.78 in 1994, in contrast to the 1992 showing of 0.59, but still failed to compete with the totals of the years prior to 1990. The 1994 CPUE for legal spiny lobster rose to 0.51 and increased slightly to 0.27 for legal slipper lobster (Table 1).

A more detailed assessment of the 1994 NWHI commercial lobster fishery is included in Administrative Report H-95-06. (R. Dollar, [808] 943-9210)

Hawaii-based Longline Fleet, First Quarter 1995

Vessel activity and effort—Preliminary results¹ show 103 Hawaii-based longline vessels made 321 trips during the first quarter of 1995. This is a decrease of 12 vessels and 60 trips in comparison to the first quarter of 1994 (Fig. 5). The decrease is a result of the emigration of longline vessels in 1994. Among entrants to the Hawaii-based longline fleet in 1995 were five vessels new to the longline fishery and one vessel which did not fish in 1994.

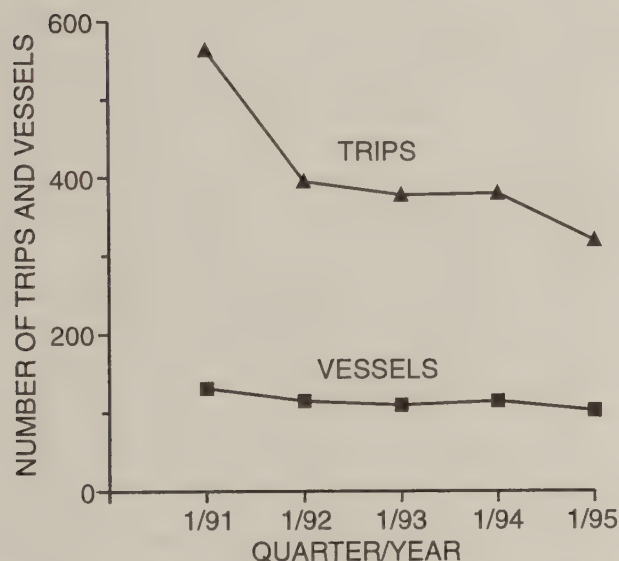


Figure 5. Number of Hawaii-based longline vessels and trips, January-March 1991-95.

The total number of hooks set was 3.7 million in the first quarter of 1995. This is a slight decrease from the 3.8 million hooks set in the first quarter of 1994 (Fig. 6). The number of hooks set inside the Hawaii Exclusive Economic Zone (EEZ) dropped 11 percent to 2.2 million while the number of hooks set outside of the EEZ increased 11 percent to 1.4 million.

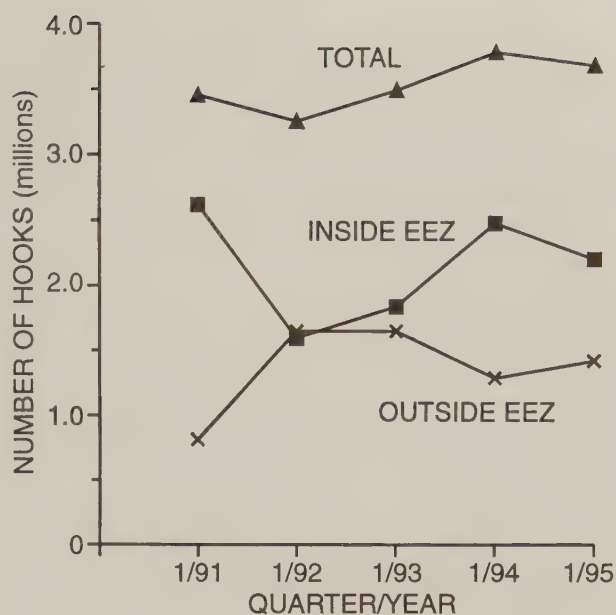


Figure 6. Number of hooks set, January-March 1991-95, Hawaii-based longline fleet.

Catch—Mahimahi, *Coryphaena hippurus*, catch increased elevenfold to an all-time high for the first quarter of 1995 ($N = 31,360$) (Fig. 7). This dramatic increase made mahimahi the largest component of the catch. Bigeye tuna, *Thunnus obesus*, catch was also at an all-time high ($N = 20,742$), making it the second largest component of the catch. Sharks, the largest component of the catch for the past 2 years,

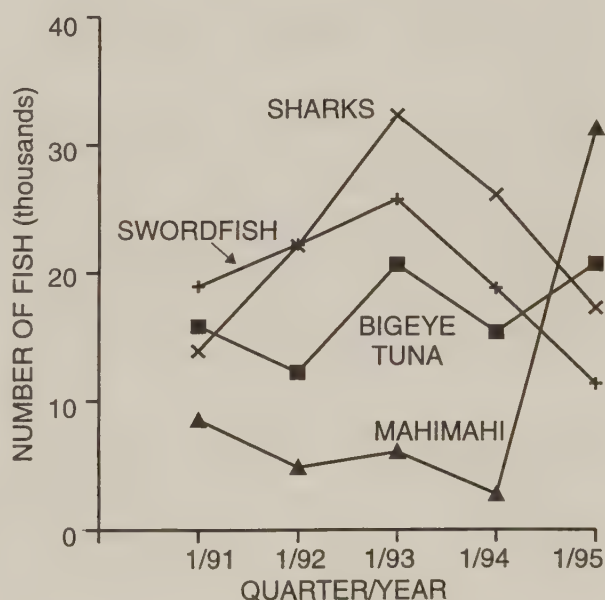


Figure 7. Number of fish caught, January-March 1991-95, Hawaii-based longline fleet.

¹Preliminary summaries in this report are based on date of haul.

slipped to third ($N = 17,289$) and swordfish, *Xiphias gladius*, catches also dropped substantially. Swordfish, which had consistently been the largest or second largest component of the catch for the first quarters of the previous 4 years, slid down to the fourth largest in 1995. The number of swordfish caught in the first quarter of 1995 was 11,352. (R. Ito, [808] 943-1213)

Hawaii Fleet Industry and Vessel Economic Project Status

The Hawaii Fleet Industry and Vessel Economics Project, a cooperative effort between the Honolulu Laboratory's Fishery Monitoring and Economics Program and the Joint Institute for Marine and Atmospheric Research (JIMAR) of the University of Hawaii, began its research in January 1994 with a cost-earnings analysis of the Hawaii-based domestic longline fishery for 1993. Research objectives of this project include (1) determining the costs, earnings, and returns (both economic and financial) for various fishery sectors, (2) determining the sensitivity of returns to changes in input/output prices and quantities, and (3) determining the levels of output (catch) or prices required for vessels to break even.

Vessel captains or owners of 100 of the 122 vessels that longlined in Hawaii in 1993 have been surveyed successfully. Responses were coded and entered into a respondent survey database and merged to obtain a vessel-level survey database. In addition, a trip-level operations and revenue database was constructed from Federal longline logbook and State of Hawaii landings reports. This information was integrated with the cost survey database.

JIMAR Economist Marcia Hamilton presented the draft results of the cost-earnings analysis at the May 1995 Tuna Conference at Lake Arrowhead, California; a draft report will be prepared by August 1995. A substantial commitment of time during late spring 1995 involved verification of summarized and categorized cost and earnings information with focus groups of vessel captains and owners and more detailed analysis of revenue.

A survey of vessel owners concerning permit sales and transfers, a second module of this project, was mailed in early 1995. Initial results were not promising because of the low response rate; however, additional efforts are being undertaken to expand the response rate and complete the analysis. This survey will determine how recent permit transfers and potential transfers may alter the nature of the Hawaii longline fishery. This has become a relevant issue because of the liberalizing of permit

transfer rules under amendment 7 to the pelagic species FMP. (M. Hamilton, [808] 943-1213)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

PFEG Moves to New Facility

After seven moves from one facility to another during its 26-year history, the Pacific Fisheries Environmental Group (PFEG) has moved into what should become its permanent facility. In April, PFEG moved from the Fleet Numerical Meteorology and Oceanography Center in Monterey to the former Naval Reserve Center in Pacific Grove. This building, constructed in the early 1950s as a radar installation, was surplus in the base closure process in 1994. Although renovated in 1989 and currently in very good condition, it had been empty during the past year awaiting a decision by the Navy whether to transfer the property to NOAA or the California National Guard. In March, the National Guard was assured of getting property and buildings at Fort Ord and removed its bid for this property, smoothing the way for NOAA to get the facility.

The building is on 4-1/2 acres of coastal dune near the ocean at Point Piños, the site of a Coast Guard lighthouse. It has approximately 7,500 square feet of usable space on three levels, including a large classroom suitable for seminars or small scientific meetings. PFEG occupies the single room on the third floor, the second floor, and part of the first floor; NMFS Enforcement staff have already moved in and there are plans for some staff of the Monterey Bay National Marine Sanctuary to move in as well. The building has been wired for PFEG's computer network and Information Technology 1995 (IT-95) system. Although use is presently under a one-year agreement with the Navy, the property should be transferred to NOAA ownership after resolution of some environmental issues. PFEG has come full circle with facilities in its 26-year history; this site was the original home of PFEG in 1969, when it was located in a trailer on the parking lot. (G. Boehlert, [408] 648-8447)

IT-95 Server Delivered to PFEG

PFEG accepted delivery of its IT-95 server on April 14 concurrently with PFEG's move to a new

facility in Pacific Grove. A Control Data Corporation contractor has been on site since May 8 to help configure the server and set up the Oracle database system. Local-area network (LAN) wiring was installed throughout the new building during the week of May 8. A wide-area network (WAN) line was installed June 23, connecting PFEG to La Jolla and the rest of NMFS.

Ogden contractors have been working on converting the Upwelling Index processing programs. The original programs were written specifically to run on the mainframe computer at the Navy's Fleet Numerical site. The mainframe is being decommissioned in August, so the programs are being converted to run on the IT-95 server. Eventually, all the upwelling data will be added to the Oracle database.

The WAN line was disconnected from the Monterey site and reconnected in Pacific Grove on June 20. This finally gave PFEG the ability to directly access the rest of NMFS and other sites on the Internet. This also gave the Tiburon Laboratory access to the PFEG server that, according to the IT-95 plan, is their host Oracle server. (LT John Steger, [408] 648-9035)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Summary of the 1994 U.S. North and South Pacific Albacore Troll Fisheries

The 1993-94 U.S. South Pacific albacore fishery extended from 130° W to 180° W between 35° S and 45° S. The fishery began in December 1993 and ended in April 1994. Participation in the fishery decreased from 47 vessels during the 1992-93 season to 14 vessels. Poor catches in recent years and warmer than normal sea surface temperatures are responsible for the decreased participation. Total landings for the 1993-94 season decreased to 603 t from 1,028 t landed in the 1992-93 season. Catch rates for the 1993-94 South Pacific season, however, increased to 79 fish per day, compared to an average catch rate of 45 fish per day for the 1992-93 season.

The average fork length of fish caught during the 1993-94 season was 66 cm (6.7 kg or 15 lbs) compared to 63 cm (5.9 kg or 13 lbs) for the 1992-93 season.

The 1994 U.S. North Pacific albacore fishery began in May 1994 north of Midway Island and ended in November 1994. More than 600 troll vessels participated in the fishery. Vessels fishing in the off-shore areas near the International Date Line and northeast of Hawaii gradually moved east as the season progressed. The largest catches sampled were centered in three regions:

1. West of the International Date Line between 173° E and 180° E from 36° N to 41° N (in June and July).
2. Between 141° W and 147° W from 41° N to 46° N (from July through October).
3. Between 125° W and 130° W from 44° N to 51° N (in August).

Total albacore landings for the 1994 North Pacific season increased for the third consecutive year to 10,535 t. Catch rates also increased to 60 fish per day from 38 fish per day in 1993. The average fork length of albacore caught during the 1994 North Pacific season was 71 cm (7.4 kg or 16 lbs) compared to an average fork length of 69 cm (6.8 kg or 15 lbs) during the 1993 season. (J. Childers, [619] 546-7192)

Fourth Quarter 1994 Seychelles Fishing Authority Data Updated

On June 14, 1995, Fishery Biologist Alan Jackson updated fourth quarter 1994 Seychelles Fishing Authority data on the tuna purse seine fishery in the western Indian Ocean. The data, based on logbook returns from fishing vessels, are summarized in Lotus spreadsheets and cover the period 1983 to the present. Estimates of catch for the current quarter may be revised upward when logbooks are eventually received for fishing trips completed too late for inclusion in this data set.

The number of vessels participating monthly in the purse seine fishery in the western Indian Ocean during the fourth quarter of 1994 averaged 45 (17 French, 17 Spanish, and a combined 11 Belizean, Liberian, Mauritian, and Panamanian vessels), virtually the same as the average number of vessels recorded for the same period the previous year. The monthly average number of vessels participating during the entire year of 1994 was 42, down from 50

vessels the previous year, primarily due to the complete disappearance of the Japanese fleet from this fishery. The number of Japanese purse seiners declined in 1993 from 11 in January to 1 in December. No Japanese seiner has participated in this fishery since January 1994. The number of vessel-days-fished in the fourth quarter of 1994 was 3,311, up 5 percent from the previous year. The number of vessel-days-fished for the entire year of 1994 was 12,130, down 16 percent.

Purse seine catches of skipjack, yellowfin, and other tunas in the western Indian Ocean in the fourth quarter of 1994 totaled 74,900 metric tons (t),

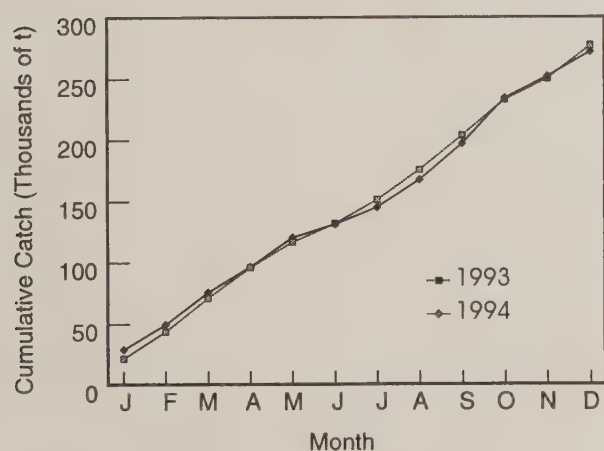


Figure 1. Cumulative catches (metric tons) of tuna by purse seiners in the western Indian Ocean, 1993-94.

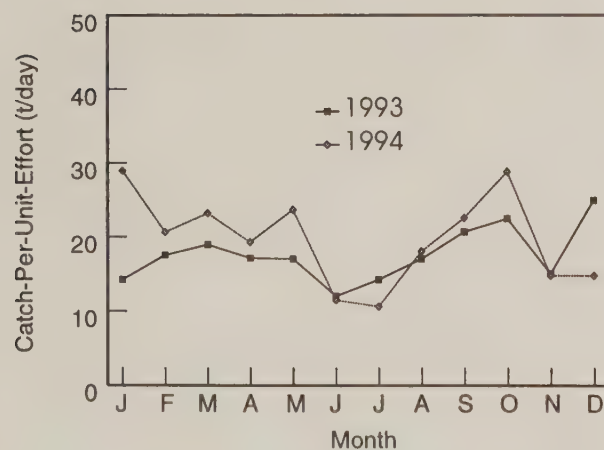


Figure 2. Catch rates (metric tons/days fished) for purse seiners fishing in the western Indian Ocean, 1993-94.

up 2 percent from the previous year. The species breakdown was 64 percent skipjack, 23 percent yellowfin, and 13 percent other tunas. For the entire year of 1994, the catches totaled 271,900 t, down 2 percent, and were composed of 55 percent skipjack, 34 percent yellowfin, and 11 percent other tunas (Fig. 1).

The catch rate for all tuna species for the fourth quarter of 1994 was 22 t per vessel-day, down 3 percent from the previous year. Catch rates for skipjack and yellowfin tunas were 15 and 5 t per vessel-day, respectively. For the entire year of 1994, the catch rate for all tunas was 22 t per vessel-day, up 16 percent, with skipjack and yellowfin tuna catch rates of 12 and 8 t per vessel-day, respectively (Fig. 2). (A. Jackson, [619] 546-7048)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Shark Abundance Indexing

The annual population abundance survey for pelagic sharks began in June. This cooperative research project with the California Department of Fish and Game consists of four 10-day sampling cruises. The first was completed onboard the research vessel *Mako* in June. Eighteen sampling longline sets were conducted in which approximately 2,000 hooks were deployed. Although all cruises have not been completed, initial CPUE rates appeared lower than in 1994.

Cruises beginning in July will be conducted from the research vessel *Yellowfin* while the final cruise scheduled in October will utilize the research vessel *Mako*. (D. Holts, [619] 546-7186)

Billfish Angler Survey and Tagging Program Update

Response to the 1994 Billfish Angler Survey was very good during this quarter, with over 400 individual anglers documenting their fishing effort and angling success.

Requests for billfish tagging supplies increased during the first half of 1995. Nearly 2,000 billfish tags were distributed to individual anglers and co-operating sportfishing clubs and resorts. Over 450 billfish were reported tagged by the end of June. Tag recoveries for 6 striped marlin, 1 swordfish, 1 sailfish, and 1 bigeye tuna also were received. (D. Holts, [619] 546-7186)

TIBURON LABORATORY

Tiburon, California

FISHERY MANAGEMENT ADVISORY

CalCOFI Index of Bocaccio Abundance Shows Severe Decline

The CalCOFI surveys catch moderate numbers of bocaccio larvae, allowing development of a larva-based index of spawning biomass. In 1986, the late John MacGregor (Coastal Fisheries Resources Division, CFRD) published summaries of bocaccio larvae from CalCOFI surveys for the years 1956, 1969, 1972, and 1975 (original data are missing). More recently, Geoff Moser et al. (CFRD) published data on density of bocaccio larvae at stations occupied by CalCOFI surveys in 1972, 1975, 1978, 1981, and 1984. Although the MacGregor and Moser data are both based on CalCOFI sampling, they are not directly comparable due to differences in data processing and summarizing. These data will soon be available on the SWFSC CalCOFI database, at which time it should no longer be necessary to mix the two different treatments.

Both sources provide data from 11 CalCOFI lines spaced at 40-mile intervals from Point Reyes to the Mexican border. The MacGregor data summarize annual abundances by CalCOFI line but do not include monthly variability. The Moser et al. data include monthly variability; not all months were sampled, but in most cases three of the four peak spawning months (January-April) contain observations. The Moser et al. data from individual CalCOFI stations were first converted to "line" abundances: station densities were multiplied by the half-distance to adjacent stations and the result was summed over the line.

The analysis was conducted using the General Linear Model (GLM) in Statistical Analysis System. The model was assumed to be additive after log transformation, and the model predicts (logged) observations as a sum of year, line, and month effects. The Moser et al. data were assigned appropriate monthly values, and the MacGregor data were assigned annual values. Since the MacGregor data are in much larger units, the data were scaled while preserving the relationships among year and line factors.

Factors were estimated by a two-stage reweighted GLM. On the first iteration, all cells were given equal weight. On the second iteration, cells were assigned weights based on the fraction of the total annual larval abundance expected in the cell according to the month and line factors from the unweighted model. This weighting prevents month-lines with typically low abundances from having a disproportionate effect on the estimated year factors. Antilogging the year factors provides the annual abundance indexes (Fig. 1).

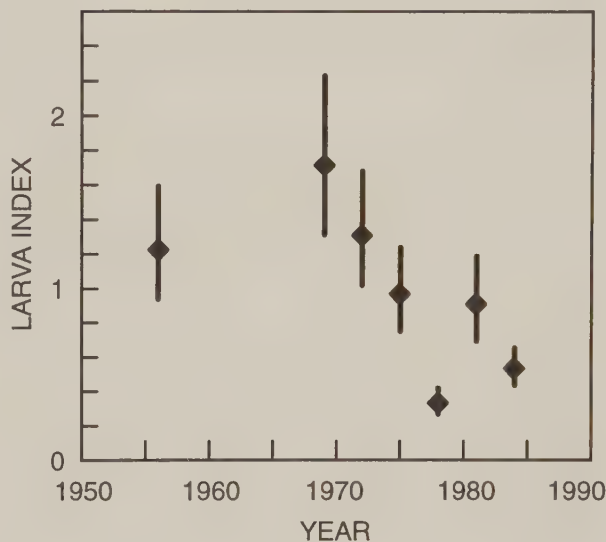


Figure 1. CalCOFI indexes of bocaccio larvae abundance.

Recent CalCOFI samples have not yet been sorted for fishes such as bocaccio, and the series cannot yet be extended beyond 1984. However, this series does suggest that bocaccio may have already experienced a substantial decline by 1980, the first year used in Jim Bence and Jean Rogers' recent (1992) stock assessment. Under four alternative scenarios, Bence and Rogers estimated 1990 spawning biomasses to be between 18 and 40 percent of 1980 values. A visual comparison suggests that by 1980, the resource may already have dropped to one-half or one-quarter of its previous level. Adding the subsequent decline estimated by Bence and Rogers suggests that by 1990 the bocaccio spawning biomass may have declined to between 5 and 20 percent of its pre-1970s level. (A. MacCall, [415] 435-3149, ext. 210)

GROUNDFISH ANALYSIS INVESTIGATION

13th Annual Juvenile Rockfish Survey Completed

Fishery biologists within the Groundfish Analysis Investigation at the Tiburon Laboratory successfully completed their 13th annual juvenile rockfish (*Sebastes* spp.) survey. The cruise was conducted from May 15 to June 19, 1995, aboard the NOAA research vessel *David Starr Jordan* and was designed to assess the distribution and abundance of pelagic-stage young-of-the-year rockfish inhabiting the coastal waters off central California.

A modified Cobb midwater trawl with a 26-meter (85-foot) headrope and 1-centimeter (1/2-

inch) liner was used to capture juvenile rockfish at 36 stations along seven transects situated between Cypress Point (Monterey County) and Point Reyes (Marin County) and to 35 miles off the coast. In 1986, the sampling protocol was changed to include three "sweeps" of the area. The trawls were fished at night for 15 minutes at depth at a speed of 2-2.5 knots. Standard trawls were fished at a headrope depth of 30-35 m, or at 8 m when in shallow water.

A Seabird SBE19 conductivity-temperature-depth (CTD) probe was used to measure temperature, salinity, light, and chlorophyll fluorescence to depths as great as 500 m at positions surrounding and including the nighttime trawl stations. Additionally, sea surface temperature (SST) and salinity were recorded continuously with a Seabird thermosalinometer and subsurface currents

Table 1. Number of pelagic young-of-the-year rockfish collected by midwater trawl at standard stations and depths during May-June cruises (1986-95).

SPECIES	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Shortbelly	9,104	6,865	107,962	1,598	4,479	2,422	2,838	2,287	966	274
Chilipepper	54	586	4,418	24	66	343	90	1,251	3	32
Brown	470	10	-	3	19	265	7	1,226	17	7
Widow	11	424	257	13	296	623	1	101	23	24
Squarespot	4	177	380	16	649	47	70	25	-	-
Canary	46	71	162	39	23	618	-	14	3	1
Blue	4	196	366	63	38	220	-	37	11	6
Stripetail	2	194	30	6	22	175	5	315	9	6
Bocaccio	327	106	60	22	44	114	5	26	4	3
Yellowtail	22	85	69	31	27	281	5	31	7	27
Copper complex	9	9	1	-	1	15	116	82	2	2
Unknown	40	-	-	-	2	4	49	31	84	27
Pygmy	2	15	9	12	10	62	8	2	3	-
Halfbanded	1	9	-	2	77	8	1	5	2	-
Black	1	22	19	5	4	34	-	6	2	1
Olive	-	4	2	6	18	-	-	6	1	-
Dark blotched	-	7	5	-	1	9	-	9	-	2
Cowcod	1	17	1	1	-	-	5	5	-	-
Bank	-	18	4	-	-	-	-	5	-	-
Splitnose	1	4	-	-	1	-	19	-	-	-
<i>Sebastomus</i> subgenus	2	7	3	-	1	3	8	-	-	1
Puget Sound	-	-	-	-	-	22	-	-	-	-
Sharpchin	-	-	-	-	-	18	2	-	-	-
Grass	1	1	-	-	-	-	8	2	-	-
Quillback	2	1	-	-	-	6	-	-	-	-
Vermillion	-	4	-	-	1	1	-	-	-	-
Greenstripe	-	3	-	-	-	-	-	-	-	-
China	-	2	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	1	-	-	-
Greenspotted	-	-	-	-	-	-	1	-	-	-
TOTALS	10,104	8,837	113,748	1,841	5,779	5,290	3,242	5,466	1,137	411

were measured with an acoustic Doppler current profiler.

Results for 1995 yielded the fewest number of juvenile fish since the three-sweep approach was initiated in 1986 (Table 1). Moreover, last year produced the second lowest catch. As has been the case in recent years, the fish were small, averaging less than 20 mm standard length. The cause of the apparently poor larval survival in 1995 may well have stemmed from the severe winter storms that occurred along the California coast in January and March. Southerly January winds resulted in the strongest downwelling conditions in at least five years. Winter is a critical period for *Sebastes* larvae. Aside from a few larger specimens, that were likely released during the calmer month of February, most of the catch was comprised of fish released in April or May, well past the peak of parturition.

Rockfish are relatively long-lived species and stocks would normally be able to withstand at least two consecutive years of poor larval survival. However, as fishing pressure reduces the mean age of the population, it becomes more critical to monitor juvenile survival so that signs of over-exploitation can be recognized early.

Regarding oceanographic patterns occurring during the cruise, typical SST readings were observed with upwelling occurring in the Point Reyes area and off Davenport (Fig. 2). The warm water

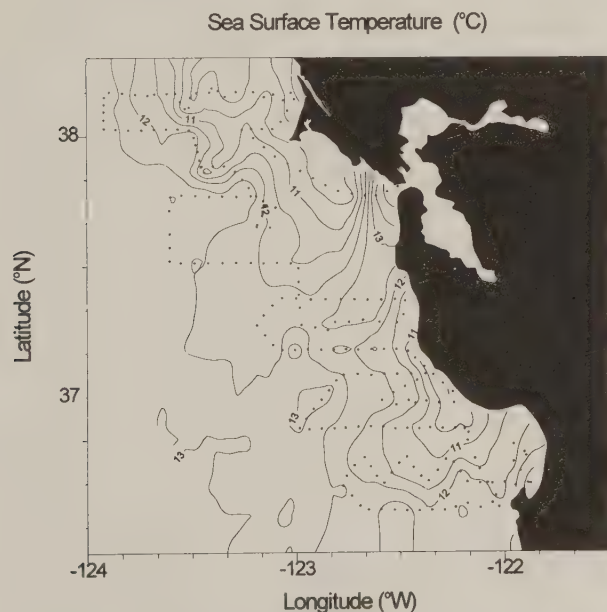


Figure 2. Contours of sea surface temperature (°C) during the second sweep of David Starr Jordan cruise 9506. The cruise track is represented by the dotted line.

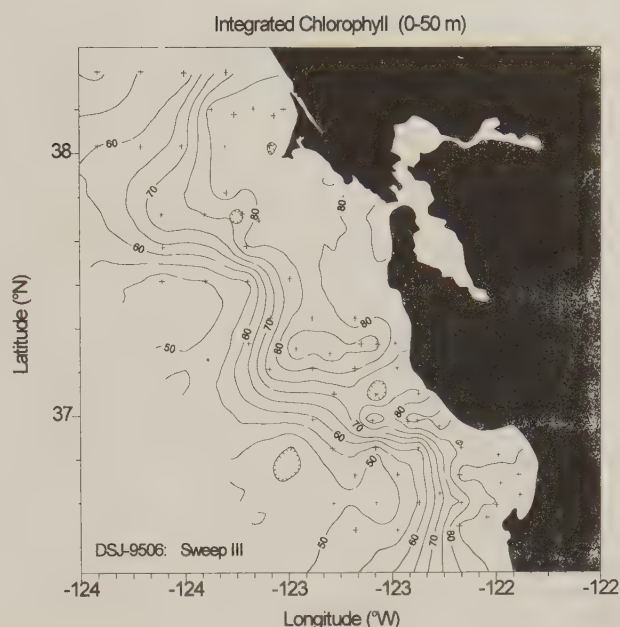


Figure 3. Contours of integrated chlorophyll (0-50 m, voltage units) observed during the third sweep of David Starr Jordan cruise 9506. Stations where data were collected are represented by plus symbols.

plume extending southwest of San Francisco Bay is the lens of freshwater outflow due to the above-average rainfall experienced during winter. This year, a fluorometer on the CTD, which measured chlorophyll concentrations ($\mu\text{g/l}$), was used for the first time. Figure 3 shows the levels of integrated chlorophyll (surface to 50 m) concentrated within the Gulf of the Farallones and Monterey Bay.

While pelagic juvenile rockfish numbers have been down over the past two years, sardine (*Sardinops sagax*) abundance during the same period of

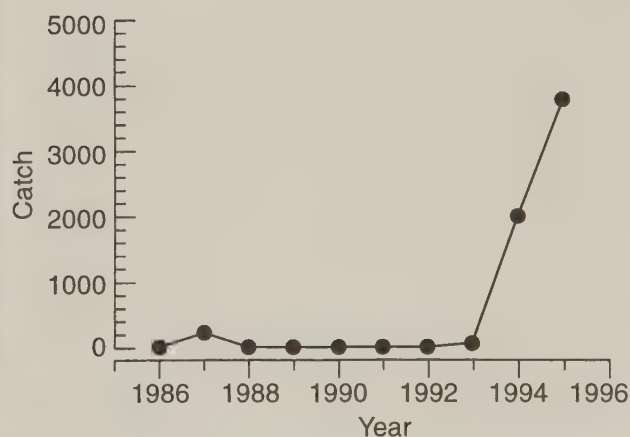


Figure 4. Number of sardines collected by midwater trawl at standard stations and depths during May-June cruises (1986-95).

time has shown a dramatic increase (Fig. 4, pg. 17). Most of the sardines that were captured this year were around 12 cm long and thus were one-year-old fish.

In addition to the midwater trawls, 76 Tucker trawls and 67 manta tows were conducted in an area off Point Reyes, including the Gulf of the Farallones and Cordell Bank. This work was conducted in collaboration with researchers from the Gulf of the Farallones National Marine Sanctuary and the University of California at Davis. In addition to larval fish, these two sampling gears captured large quantities of euphausiids and crab megalopae. The distribution of these invertebrate taxa around the Point Reyes upwelling plume is being studied, as are abundance patterns of young-of-the-year *Sebastes* spp. In particular, rockfish and Dungeness crab megalopae appear to be transported north along the coast and to settle in nearshore areas as upwelling conditions relax. (D. Woodbury and S. Ralston, [415] 435-3149, ext. 218 and 229)

GROUNDFISH PHYSIOLOGICAL ECOLOGY INVESTIGATION

Rockfish Embryonic and Larval Development and Energy Utilization

Rockfishes are viviparous fishes which collectively comprise an important component of the Pacific coast groundfish fishery. Annual surveys of *Sebastes* larvae and pelagic juveniles have shown significant interannual variation in abundance and distribution. Contributing to this variability is high larval mortality in the first few days following release from the mother. Recent laboratory experiments and field investigations of yellowtail rockfish have demonstrated that embryos and larvae derive most of their nutrition throughout development from endogenous sources, although some maternal contributions are provided (see *Fishery Bulletin*, 1995, Volume 93, p. 299-307, and *Journal of Experimental Biology*, 1995, Volume 198, p. 1197-1206).

To determine the rate of utilization of endogenous energy sources by early life stages and the amounts that remain at the time of parturition, we conducted laboratory experiments with pregnant yellowtail rockfish. Adult females were collected from Cordell Bank, California, by hook and line and transported live to 2000-liter tanks at the University of California Bodega Marine Laboratory.

A total of 16 fish over four reproductive seasons were successfully monitored and sampled through gestation. Fish were periodically anesthetized and their eggs subsampled by catheter to determine the stages of development. Two females provided the opportunity to examine eggs from late vitellogenesis through embryogenesis, hatching, larval development, and final parturition.

Egg and larval specimens were preserved in 10 percent buffered formaldehyde and allowed to harden for a period of 1-3 months. Tissues were dried for 24-36 h at 100 °C. Eggs, embryos, and larvae were then dissected under the microscope to provide duplicate weight measures of chorions, yolks, and assimilated tissues. Estimates of oil globule weights were obtained by subtraction of yolk and tissue (and chorion when appropriate) combined weights from the total egg weights. All measurements were made on an ultrabalance to the nearest 0.0001 milligram.

Chorions amounted to 6.8 and 10.4 percent of the total egg weight. Endogenous energy reserves contained in the yolk (Fig. 5) were utilized to an average of 37 percent by the time of hatching (23 days postfertilization) and to approximately 12 percent by parturition (33 days postfertilization). The oil globule energy picture was not as clear, with one of the fish exhibiting varying amounts of remaining oil up to the time of hatching. In embryos and larvae from the examined females, however, oil reserves were essentially exhausted by parturition time.

Tissue assimilation throughout gestation was continuous and linear. Released larval weights at parturition were similar at 306 and 332 micrograms average weights. Conversion efficiencies by weight, however, differed, 49 versus 73 percent, in large part because of the differences found in the amount of oil globule weights. Further studies are underway to clarify this issue.

Findings in this study show that yellowtail rockfish maximize their utilization of endogenous energy reserves for early life stage development prior to parturition. Newly released larvae retain limited endogenous reserves at parturition, which implies that exogenous food must be obtained soon for growth and survival, probably within days. These laboratory results support field observations and suggest that adequate microzooplankton food supplies are critical for larval rockfish survival. (M. Eldridge, [415] 435-3149, ext. 243)

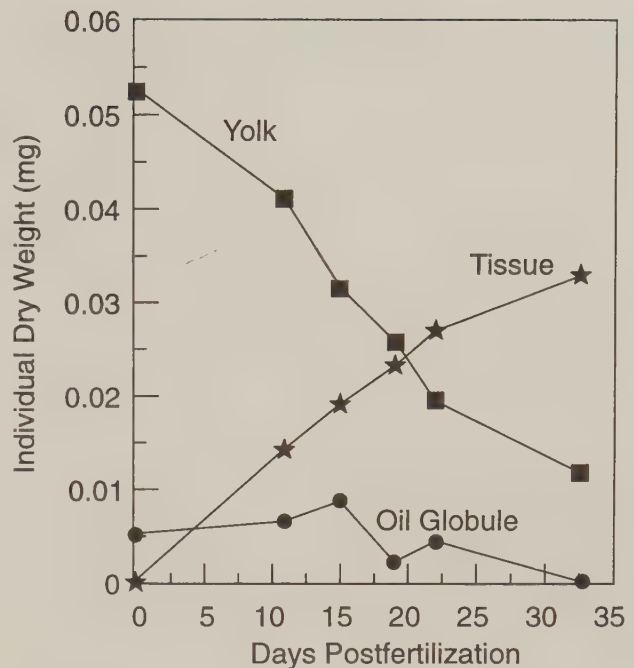
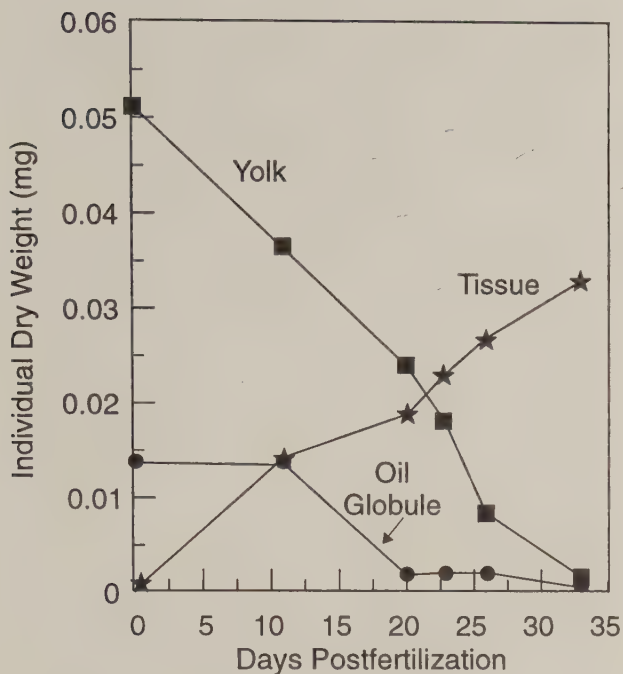


Figure 5. Average weights of yolk (squares), oil globule (circles), and tissue (stars) of embryos and larvae subsampled from two adult yellowtail rockfish held in aquaria throughout gestation. Hatching occurred at 23 days postfertilization and parturition occurred on day 33.

INFORMATION TECHNOLOGY SERVICES

New Administrative Systems

The SWFSC is scheduled to implement the NMFS Financial Reporting System (FRS) on October 1, 1995. The system was originally developed and used in the Northeast Fisheries Science Center and is being modified to run at the national level in a distributed mode. Each NMFS Financial Management Center (FMC) will have the FRS system installed on one of its IT-95 computers for local data entry and reportings, and databases from each NMFS FMC will be linked so that national-level reports can be obtained as needed. The La Jolla Laboratory held an NMFS FRS training session on June 1 and 2, 1995, using a temporary copy of the FRS installed on the La Jolla IT-95 host. About 20 people from the SWFSC and the Southwest Region attended the training.

The NMFS Management Information System (MIS), a new system currently in the prototype

stage, includes information on all NMFS activities, personnel, budgets, assets, plans, and products, and allows each FMC to enter local data and transmit the information to headquarters for consolidation. An MIS workshop was held in Silver Spring, Maryland, June 13-15, 1995, for representatives from all NMFS regions and headquarters to understand the system and regional needs. An enhanced version of the current prototype will be released in August.

The Commerce Administrative Management System (CAMS) is a new computer system under development that will replace existing agency financial and functional systems. At its heart is a Core Financial System (CFS) made up of many integrated modules, including general ledger and financial reporting, payment management, receipts management, funds management, cost accumulation, and allocation, that will be integrated with other departmentwide systems such as travel, procurement, real and personal property, personnel, and payroll. The system is designed and built using the Oracle Relational Database Management System. NOAA is scheduled to start using CAMS in October 1996. (R. Bistodeau, [619] 546-7055)

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- Juvenile loggerhead turtles (*Caretta caretta*) have recently been documented in the vicinity of Baja California, and thousands of these animals have been captured in oceanic fisheries of the North Pacific. The presence of loggerhead turtles in the central and eastern North Pacific is a prominent enigma in marine turtle distribution because the nearest documented nesting concentrations for this species are in Australia and Japan, over 10,000 km from Baja California. To determine the origin of the Baja California feeding aggregate and North Pacific mortalities, samples from nesting areas and pelagic feeding aggregates were compared with genetic markers derived from mtDNA control region sequences. Overall, 57 of 60 pelagic samples (95%) match haplotypes seen only in Japanese nesting areas, implicating Japan as the primary source of turtles in the North Pacific Current and around Baja California. Australian nesting colonies may contribute the remaining 5% of these pelagic feeding aggregates. Juvenile loggerhead turtles apparently traverse the entire Pacific Ocean, approximately one-third of the planet, in the course of developmental migrations, but mortality in high-seas fisheries raises concern over the future of this migratory population.
- Brill, R. W., G. H. Balazs, K. N. Holland, R. K. C. Chang, S. Sullivan, and J. C. George. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian Islands. *J. Exp. Mar. Biol. Ecol.* 185:203-218.
- Depth-sensitive ultrasonic transmitters monitored the vertical and horizontal movements of 12 juvenile (<65 cm carapace length) green turtles (*Chelonia mydas*) in Kaneohe Bay, Oahu, Hawaii. This site was chosen because of its accessibility, its importance as a foraging area, and the high incidence (~50%) of fibropapillomatosis, a tumor disease of unknown etiology. Our objectives were to determine the daily movements, habitat use, and submergence intervals of normal and tumor-bearing animals. The presence of tumors had no obvious effects on movements or habitat use. All turtles remained within a small portion of the bay where patch reefs and shallow coral-covered areas are common and algal growth most abundant. During daylight, two normal and two tumor-bearing animals remained within known feeding areas, all other turtles studied stayed within deep mud bottom channels or within crevices on the sides of the reefs. All, except one tumor-bearing turtle, moved up on to shallow patch reefs or shallow coral-covered areas at night. Submergence intervals for both groups were short (over 90% were 33 min or less and none exceeded 66 min) compared to maximum breath-hold times (up to 5 h) measured in the laboratory by earlier workers. Juvenile green turtles in Hawaii, therefore, most likely maintain aerobic metabolism while submerged and surface before oxygen stores are significantly depleted. Tumor-bearing turtles had a higher frequency of longer submergence intervals during the night, indicating they may have been somewhat less active at night. Normal turtles showed no such day-night difference.
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- Churnside, J. H., K. Bliss, R. Dotson, and R. Lynn. 1995. Data report: *In situ* data from 1994 LIDAR cruise of R/V David Starr Jordan. NOAA Data Report, Boulder, Colorado, ERL-ETL-5, 53 p.

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The effect of environmental variability on marine population dynamics remains a challenging problem for fisheries science. The impact of four decades of environmental change on larval abundance of the northern anchovy (*Engraulis mordax*) off California is analyzed using recently developed nonlinear statistical techniques that extend linear multiple regression analysis. The three techniques used are: alternating conditional expectation, additivity and variance stabilization, and generalized additive interactive modeling. The dependencies of larval abundance on upwelling intensity and total anchovy biomass are nonlinear and account for 84% of the interannual variability; a linear regression analysis explained 37% of the variance. The higher larval abundances are produced with medium to large adult biomasses coupled with moderate upwelling intensity. These empirical results suggest that marine populations will respond to climatic trends, but will do so in a nonlinear manner. These nonlinear statistical algorithms, which are not yet widely used in ecology, provide a promising method for exploring the form of the relationships between environmental changes and populations responses.

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Fecundities of the commercially important yellowtail rockfish *Sebastes flavidus* were compared to determine interannual variability and geographic variation, which will assist in stock assessment, characterization, and management. Gravimetrically estimated fecundities were compared in 1985-1991 between California, the southern extent of the species' distribution, and coastal waters of Washington, near the center of the species' abundance, where yellowtail rockfish are most heavily fished. California yellowtail rockfish were older, smaller in weight and length, and had smaller mesenteric fat deposits and more extensive disease and parasite pathologies than Washington fish. Egg production of this comparatively fecund viviparous fish increased linearly and sigmoidally with body weight and length, and asymptotically with age. Significant interannual differences were found in fecundities of young fish (<age 15) from California while no differences were observed in older California fish (>age 14) or in young or old Washington fish. Washington yellowtail rockfish had higher group fecundities because they were larger at age. Rate-specific fecundities were significantly higher in young

Washington fish. Predictive models of fecundity were highly correlated for young yellowtail rockfish, less so for old fish. Although fecundity of young fish depended on weight, length, and age, that of old fish was age-independent. Our findings show age-dependent interannual and geographic differences in reproductive effort, which suggest population-specific reproductive life histories.

Ellis, D. M., and E. E. DeMartini. 1995. Evaluation of a video camera technique for indexing abundances of juvenile pink snapper, *Pristipomoides filamentosus*, and other Hawaiian insular shelf fishes. *Fish. Bull., U.S.* 93:67-77.

Bottom longline and baited video camera operations were conducted at 39 stations off the Hawaiian Islands of Oahu, Maui, and Kauai during 1992. Objectives of the 1992 cruise were to assess the precision, accuracy, and efficiency of a video camera system versus a traditional abundance index (longline catch per unit effort [CPUE]) for juvenile pink snapper ("opakapaka"), *Pristipomoides filamentosus*, a commercially important eteline snapper in Hawaii. Precision of the video samples was reevaluated with data from 18 stations sampled during 1993 off Kaneohe Bay. The video index of maximum number of opakapaka observed (MAXNO, the natural log-transformed mean of three camera drops) was best correlated with the log of longline CPUE ($r = 0.79$, $P < 0.001$, $n = 15$). Variation in the data for video MAXNO was nominally less than that of the longline CPUE. No monotone trend over stations was noted in samples from 1993. Sample sizes of 33 stations for longline and 18 stations for video would be necessary to detect twofold changes in abundance of opakapaka at a site, based on our analysis of the two end positions of the 10 windward Oahu stations that had three quantitative deployments. Re-analysis of power using data from the 1993 cruise indicates that a sample size of approximately 22 stations ($\alpha_2 = 0.05$) or approximately 17 stations ($\alpha_2 = 0.1$) would be necessary to detect twofold changes.

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Greene, H. G., M. M. Yoklavich, D. Sullivan, and G. M. Cailliet. 1995. A geophysical approach to classifying marine benthic habitats: Monterey Bay as a model. Alaska Dep. Fish and Game Special Publication Series No. 9:15-30.

Hassett, R. P., and G. W. Boehlert. 1995. Seasonal vertical, and horizontal distribution of four species of copepods around Oahu, Hawaii: Data Report. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-215, 21 p.

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He, X., and C. H. Boggs. 1995. Fishing vessel as predator: The ideal free distribution and vessel movement in the Hawaii longline fishery. (Abstr.) The 46th Tuna Conference, Lake Arrowhead, California, May 14-17, 1995.

Herrick, Jr., S. F., I. Strand, D. Squires, M. Miller, D. Lipton, J. Walden, and S. Freese. 1994. Application of benefit-cost analysis to fisheries allocation decisions: the case of Alaska walleye pollock and Pacific cod. *N. Amer. J. Fish. Mgmt.* 14:726-741.

Hopkins, T. E., M. B. Eldridge, and J. J. Cech, Jr. 1995. Metabolic costs of viviparity in yellowtail rockfish, *Sebastes flavidus*. *Environ. Biol. Fishes* 43:77-84.

We estimated the energy utilized by developing embryos and larvae of yellowtail rockfish, *Sebastes flavidus*, by determining the routine metabolic rate of adult females throughout gestation and subtracting the mean metabolic rate of non-gestating fish. The pattern of maternal oxygen consumption during gestation was such that metabolic demands did not become significantly elevated until intra-ovarian embryos had hatched and larvae were being incubated (i.e., 24-28 d post-fertilization). Metabolic rates of females in this latter stage of gestation were 82% higher than spent females and 101% higher than those of non-reproductive males. We determined that $0.08996 \text{ cal embryo}^{-1}$ was consumed during gestation as compared to the change in energy content of embryos from fertilization to birth which was $0.08690 \text{ cal embryo}^{-1}$. The difference between the energy consumed and the energy lost during the 29 d gestation period indicated that extra embryonic sources contributed only 3.4% or $0.00306 \text{ cal embryo}^{-1}$ of the energy utilized after fertilization. Our observations agree with previous work which determined that embryos and larvae of *S. flavidus* are primarily lecithotrophic and that the relatively high fecundity of *S. flavidus* coupled with a small egg size, rapid embryogenesis and brief gestation period characterize this species as a relative r-strategist within a genus whose species range broadly over the 'K end' of the r-K continuum.

Johanos, T. C., L. M. Hiruki, and T. J. Ragen. 1995. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1992. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-216, 128 p.

Laidig, T. E., and S. Ralston. 1995. The potential use of otolith characters in identifying larval rockfish (*Sebastes* spp.) *Fish. Bull.* 93:166-171.

MacFarlane, R. B., and M. J. Bowers. 1995. Matrotrophic viviparity in the yellowtail rockfish *Sebastes flavidus*. *J. Exp. Biol.* 198:1197-1206.

A capacity for matrotrophic viviparity was established in the yellowtail rockfish, *Sebastes flavidus* (Teleostei: Scorpaeniformes). The incorporation of radiolabel into embryos from [^{14}C] phosphatidylcholine present in the maternal serum during gestation provided the first in vivo demonstration of matrotrophy of phospholipid for any viviparous teleost and of any nutrient

for a member of the genus *Sebastes*. Radiolabel content increased as embryos progressed through ontogeny. Serum proteins of 170kDa, present in vitellogenic and embryogenic females, but not in earlier stages, in immature females or in males, indicated the presence of vitellogenin in pregnant females and, thus, the potential for matrotrophic supplementation to yolk sequestered before fertilization. The retention of higher molecular mass proteins and highly phosphorylated proteins and the maintenance of total protein content in yolk during early to mid embryogenesis argue for exogenous maternal supply during gestation. As ovarian development proceeded from the oocyte through successive embryonic stages, the distribution of yolk proteins shifted from higher (67-97kDa) to lower molecular masses (<70kDa). The results of these experimental studies corroborate data from field investigations showing that yellowtail rockfish can matrotrophically supplement embryo nutrients obtained before fertilization. Thus, yellowtail rockfish represent a teleost species positioned within the viviparity continuum and not at its extremes.

Matsuura, Y., and R. Hewitt. 1995. Changes in the spatial patchiness of Pacific mackerel, *Scomber japonicus*, larvae with increasing age and size. *Fish. Bull., U.S.* 93:172-178.

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Nutritional dynamics of yellowtail rockfish, *Sebastes flavidus*, were analyzed from the perspective of temporal changes in tissue composition of liver, muscle, mesentery, and gonad to determine aspects specific to female reproduction. Monthly tissue composition data over an annual reproductive cycle indicated that females accumulated greater somatic tissue energy reserves than did males during the summer and fall months. Maternal lipid and protein reserves were depleted in a reciprocal relation with ovarian growth during the winter. The greatest declines of lipid and protein occurred in mesenteries and muscle, respectively. Females lost approximately 40% more somatic tissue than males during the time interval from ovarian development to parturition. Lipid was the primary energy source, contributing 74% of the energy lost from somatic tissues for female-specific reproductive purposes. Two-thirds of lipid depleted from maternal soma was for adult metabolic maintenance. Of the other one-third, 43% was gained in ovary tissue during development, leaving 57% for reproductive metabolic costs. Protein increased 220% in ovaries relative to female-specific somatic protein loss, indicating de novo ovarian synthesis. This study is the first report of comprehensive tissue composition dynamics and allocation to reproduction in a viviparous marine teleost. The analytical design used demonstrated the significance of each tissue component and the temporal pattern of allocation to reproductive development.

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- Polovina, J. J., and R. B. Moffitt. 1995. Spatial and temporal distribution of the phyllosoma of the spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands. Bull. Mar. Sci. 56:406-417.
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Administrative Reports

Administrative Reports are strictly for internal use only and are not to be cited or treated as publications.

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UNITED STATES
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHWEST FISHERIES SCIENCE CENTER
8604 LA JOLLA SHORES DRIVE
P.O. BOX 271
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PENALTY FOR PRIVATE USE, \$300

THIRD CLASS